IN THE UNITED STATES PATENT & TRADEMARK OFFICE

APPLICANT: MICHAEL E. TOMPKINS AND MICHAEL J. GREEN	§ §	GROUP ART UNIT: 2314
SERIAL NO.: 08/162,420	§ § §	EXAMINER: E. Ramirez
FILED: December 3, 1993	§ §	
FOR: SPA CONTROL SYSTEM	§	Batch No.: B54

PETITION TO WITHDRAW APPLICATION FROM ISSUE

Commissioner of Patents & Trademarks
Washington, D.C. 20231

Date: February 7, 1995
Docket No.: 86-1198-06

Sir:

Applicant respectfully petitions to have U.S. Serial No. 08/162,420 withdrawn from Issue pursuant to 37 C.F.R. §1.313(b)(5). The Assignee of the present invention recently (after June 10, 1994, the date of allowance) has learned of prior art patent, U.S. Patent No. 4,332,297, during the course of related litigation on a commonly assigned patent. The Assignee of the present application desires the Examiner to review U.S. Patent No. 4,332,297 (a copy of which is attached as Exhibit A) when passing on the allowability of this application. On September 9, 1994, the Assignee filed with the Office an advertisement that appeared in the November 3, 1986 (Vol. 25, No.21) issue of *Pool & Spa News*. A copy of this advertisement is attached as Exhibit B. Assignee also requests the Office to consider this advertisement. The Assignee understands that the application currently is in the Draft Branch, and no issue date has been assigned. The fee for this Petition may be charged to Deposit Account No. 15-0697 of David Ostfeld, P.C.

The Assignee owns U.S. Patent No. 5,361,215, which has a common parent with this application. On November 14, 1994, Assignee filed suit in the Southern District of Texas on U.S. Patent No. 5,361,215. The defendant in that case has argued in subsequent pleadings that the '215 patent is invalid based upon U.S. Patent No. 4,322,297.

The Assignee request that the Office consider U.S.Patent No. 4,322,297 and the *Pool& Spa News* advertisement. Consequently, the Assignee requests the Office to withdraw

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(2) *Document Reconstruction Insurance.* Non-negotiable documents are insured against loss, damage or rifling up to $50,000 per piece subject to a limit of $500,000 per occurrence.
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Claims:
(1) Claims for delay, loss, damage or rifling must be made within 90 days. Claim forms may be obtained and filed at any post office.
(2) The Customer Receipt must be presented when a claim is filed.

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Please place your receipt stamp hereon thereby acknowledging receipt of papers relating to the MICHAEL E. TOMPKINS AND MICHAEL J. GREEN SPA CONTROL SYSTEM application, S.N. 08/162,420 Filed 12-03-93.

Respectfully,

David M. Ostfeld

Encl.-Petition to Withdraw Application From Issue with
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GROUP

SIEGEL/86-1198-06
DMO/dgd 02-07-95

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United States Patent [19]

Bajka

[11] **4,322,297**

[45] **Mar. 30, 1982**

[54] **CONTROLLER AND CONTROL METHOD FOR A POOL SYSTEM**

[76] Inventor: **Peter Bajka, 725 Casita Way, Los Altos, Calif. 94022**

[21] Appl. No.: **178,931**

[22] Filed: **Aug. 18, 1980**

[51] Int. Cl.³ **B01D 35/02; C02B 1/02**

[52] U.S. Cl. **210/742; 210/102; 210/103; 210/138; 210/169; 210/181**

[58] Field of Search 210/742, 102, 103, 138–143, 210/180, 181, 169

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,012,156	12/1961	Simmons	210/142 X
3,394,813	7/1968	Phillips et al.	210/149
3,809,116	5/1974	Sanner	137/391
3,906,928	9/1975	Wright	126/271
3,991,742	11/1976	Gerber	126/271
4,115,877	9/1978	Wall	210/169
4,187,175	2/1980	Roberts et al.	210/149 X
4,224,154	9/1980	Steininger	210/142 X

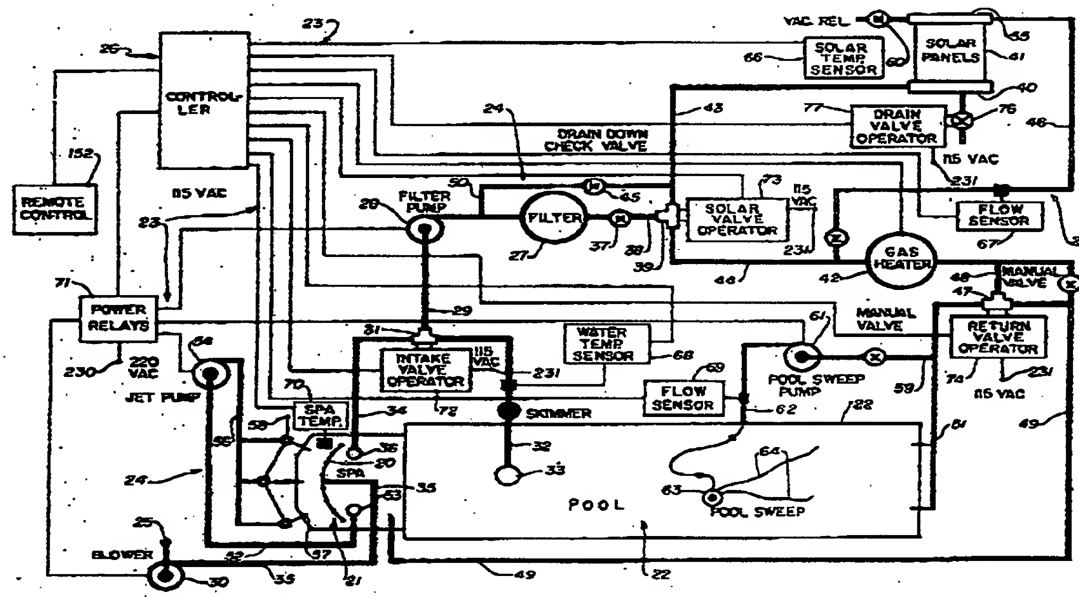
Primary Examiner—John Adee

Attorney, Agent, or Firm—Manfred M. Warren; Robert B. Chickering; Glen R. Grunewald

[57] **ABSTRACT**

A controller and method for controlling the operation of electrically powered pool related apparatus in recreational pool system, and more particularly for controlling the flow of pool water through the pool system and water-conditioning apparatus, is disclosed. The controller includes a logic circuit formed with a plurality of logic gates coupled to pool-water-sensing apparatus and programmable input apparatus in accordance with a predetermined logic sequence. The pool system includes a swimming pool and spa, and the pool-water-conditioning apparatus includes a solar water heater and a non-solar water heater. The controller is capable of preferential solar heating and of temperature-switched operation, time-switched operation and a combination thereof, as well as manual switching.

29 Claims, 6 Drawing Figures



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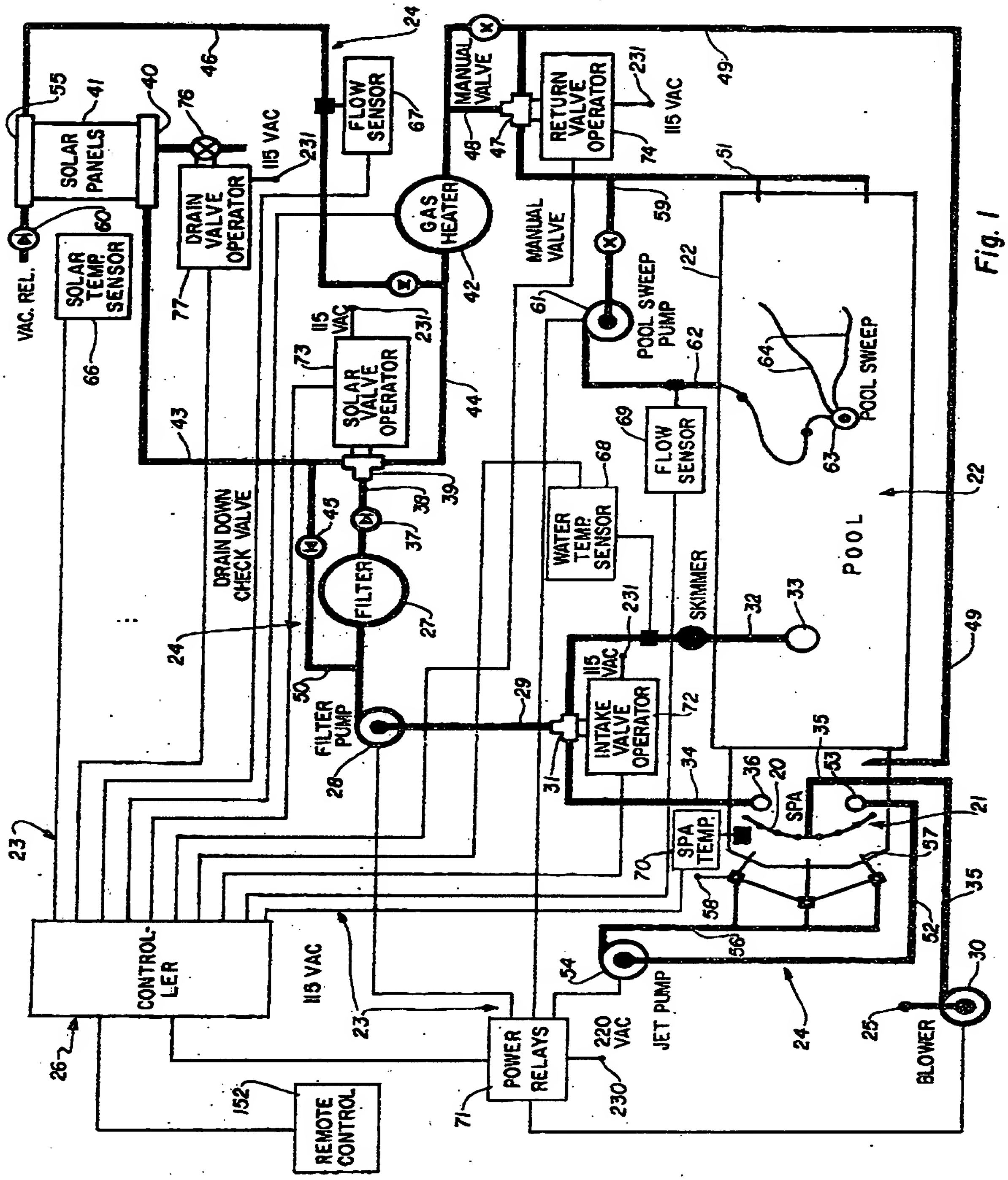
SOLAR PANELS
VAC. REL.
SOLAR TEMP SENSOR
DRAIN VALVE OPERATOR
115 VAC
FLOW SENSOR
GAS HEATER
MANUAL VALVE
RETURN VALVE OPERATOR
115 VAC
SOLAR VALVE OPERATOR
115 VAC
MANUAL VALVE
POOL SWEEP PUMP
POOL SWEEP
FLOW SENSOR
DRAIN DOWN CHECK VALVE
FILTER
WATER TEMP SENSOR
SKIMMER
POOL
FILTER PUMP
INTAKE VALVE OPERATOR
115 VAC
SPA
SPA TEMP
CONTROL-LER
115 VAC
POWER RELAYS
220 VAC
JET PUMP
BLOWER
REMOTE CONTROL

Fig. 1

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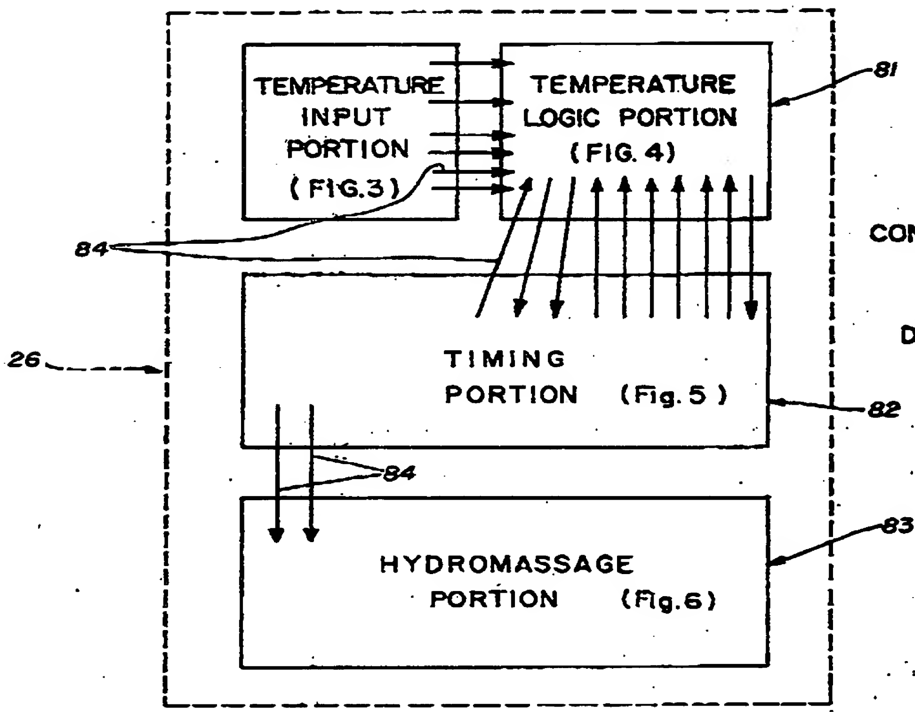
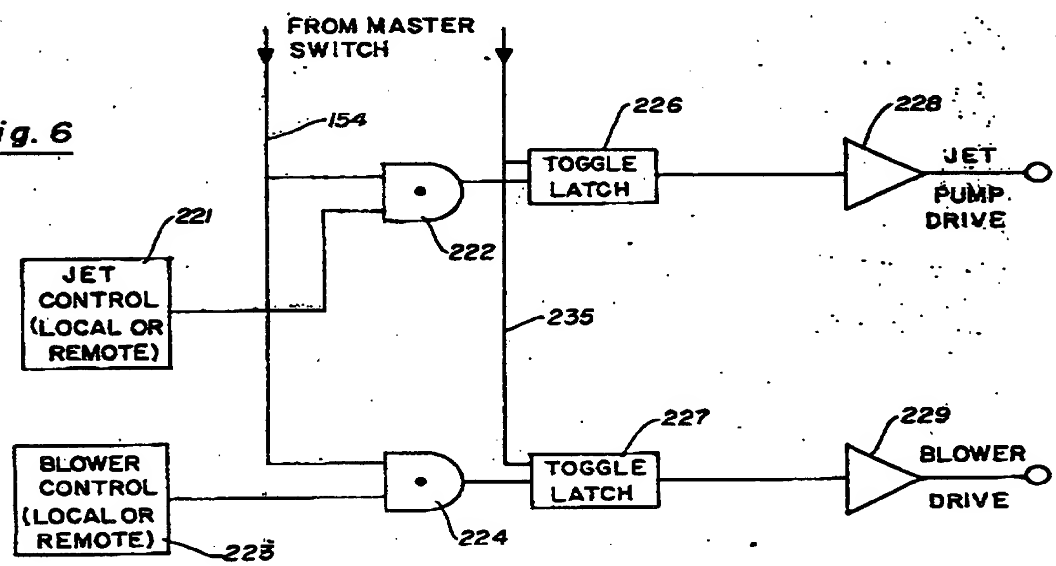


KEY TO CONTROLLER BLOCK DIAGRAM

Fig. 2

Fig. 6



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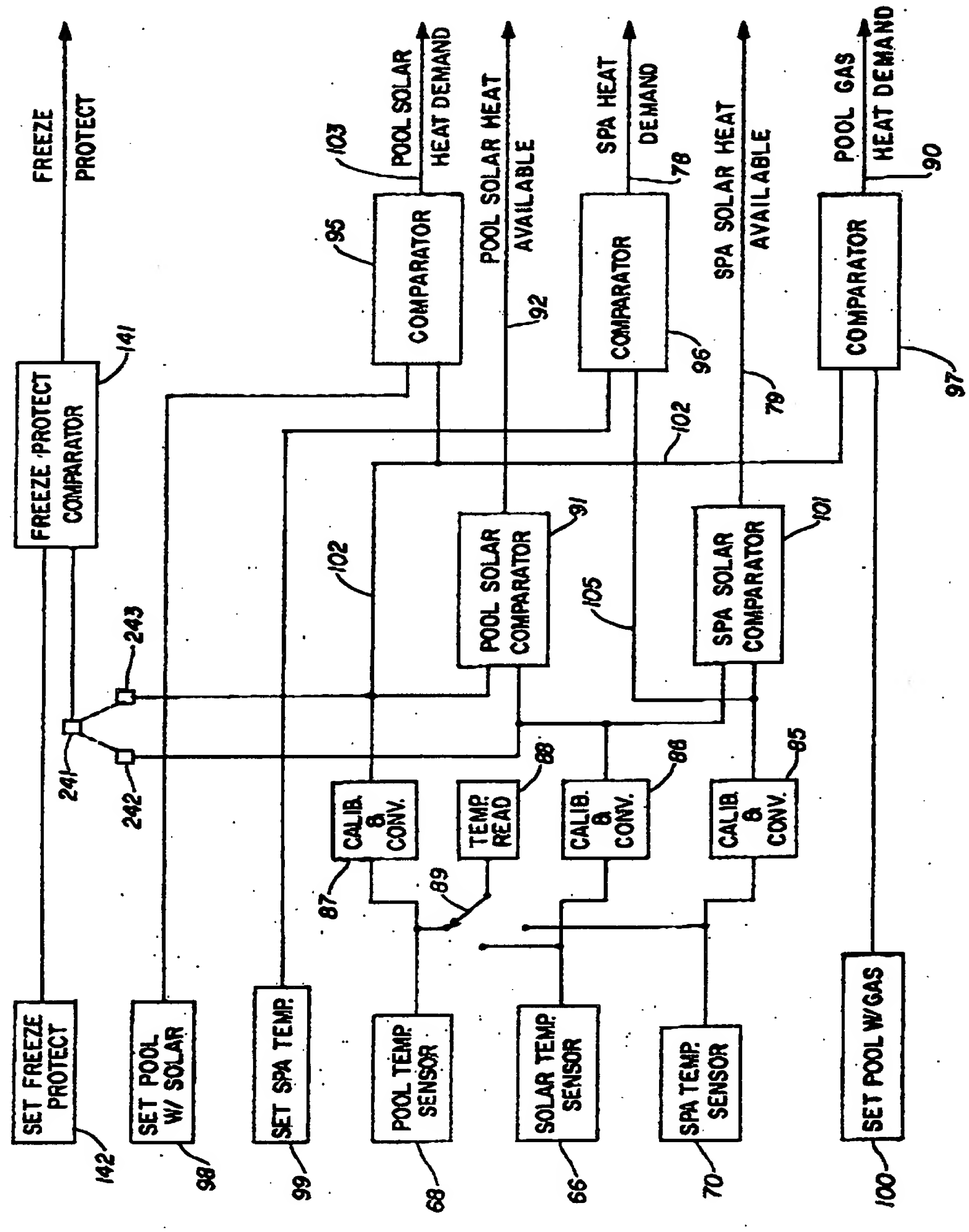
FREEZE PROTECT
FREEZE PROTECT COMPARATOR
141
POOL SOLAR HEAT DEMAND
103
95
COMPARATOR
POOL SOLAR HEAT AVAILABLE
92
SPA HEAT DEMAND
78
COMPARATOR
96
SPA SOLAR HEAT AVAILABLE
79
POOL GAS HEAT DEMAND
90
COMPARATOR
97
102
POOL SOLAR COMPARATOR
91
105
SPA SOLAR COMPARATOR
101
243
241
242
CALIB. & CONV.
87
TEMP. READ
88
CALIB. & CONV.
86
CALIB. & CONV.
85
89
SET FREEZE PROTECT
142
SET POOL W/ SOLAR
98
SET SPA TEMP.
99
POOL TEMP. SENSOR
68
SOLAR TEMP. SENSOR
66
SPA TEMP. SENSOR
70
SET POOL W/GAS
100

Fig. 3

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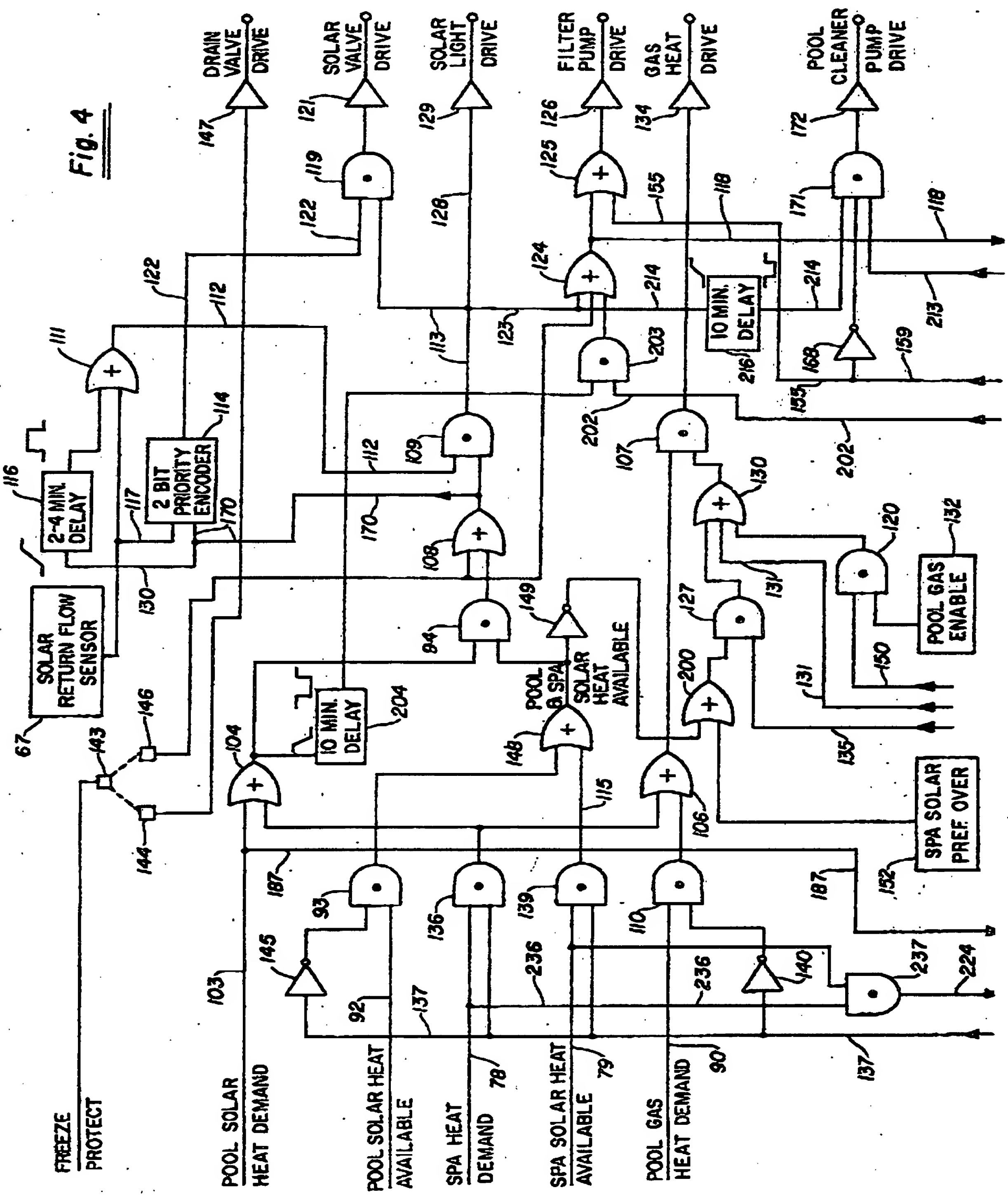
Fig. 4
DRAIN VALVE DRIVE
SOLAR VALVE DRIVE
SOLAR LIGHT DRIVE
FILTER PUMP DRIVE
GAS HEAT DRIVE
POOL CLEANER PUMP DRIVE
2-4 MIN. DELAY
2 BIT PRIORITY ENCODER
SOLAR RETURN FLOW SENSOR
10 MIN. DELAY
10 MIN. DELAY
POOL & SPA SOLAR HEAT AVAILABLE
POOL GAS ENABLE
SPA SOLAR PREF. OVER
FREEZE PROTECT
POOL SOLAR HEAT DEMAND
POOL SOLAR HEAT AVAILABLE
SPA HEAT DEMAND
SPA SOLAR HEAT AVAILABLE
POOL GAS HEAT DEMAND

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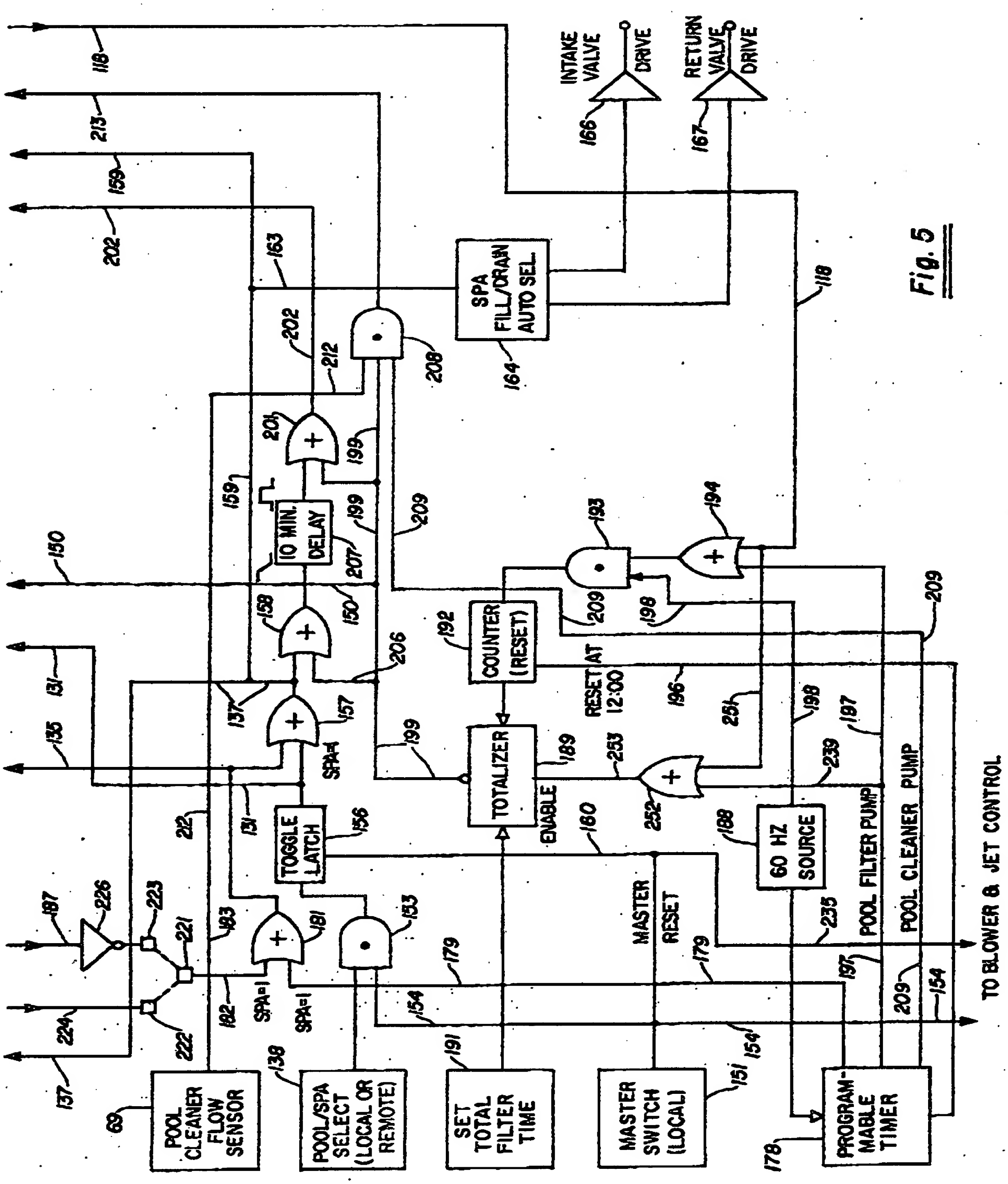
INTAKE VALVE DRIVE
RETURN VALVE DRIVE
SPA FILL/DRAIN AUTO SEL.
10 MIN. DELAY
COUNTER (RESET)
RESET AT 12:00
TOTALIZER
ENABLE
TOGGLE LATCH
60 HZ SOURCE
MASTER RESET
POOL FILTER PUMP
POOL CLEANER PUMP
TO BLOWER & JET CONTROL
POOL CLEANER FLOW SENSOR
POOL/SPA SELECT (LOCAL OR REMOTE)
SET TOTAL FILTER TIME
MASTER SWITCH (LOCAL)
PROGRAM-MABLE TIMER
SPA=1

Fig. 5

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CONTROLLER AND CONTROL METHOD FOR A POOL SYSTEM

BACKGROUND OF THE INVENTION

The recreational pool industry has experienced two dramatic trends that have affected the industry in a pervasive manner. First, the energy crisis has hastened the development of solar energy water-heating apparatus, and today there are numerous solar-energy-based systems which are quite practical and in widespread use in connection with heating pool water. The second recent phenomenon is the widespread popularity of spas or hot tubes, which are installed and used alone or in conjunction with swimming pools.

The energy crisis and the increased interest in and the popularity of spas inherently pose some degree of conflict. Spas normally operate at water temperatures in excess of 90° F. and typically include water jets or the like for circulation of the water and for hydromassage. Both increased water temperature and water circulation require the use of energy. By contrast, however, a spa is a much smaller body of water than a swimming pool, making the total heat required less and the ability to conserve heat by covering the smaller pool of water is more practical.

One area in which efforts to conserve energy have been largely overlooked has been in connection with control apparatus for controlling the operating conditions of the water in a pool system. U.S. Pat. No. 3,991,742 discloses a swimming pool system which employs both a gas heater and a solar heater. The swimming pool filter pump is used to pump water to either the solar heater or the gas heater and subsequently to return the water to the pool. The thrust of U.S. Pat. No. 3,991,742 is directed to the construction of the solar heating apparatus or panels, not a system or apparatus for controlling the flow of pool water as between the solar panels and the gas heater.

In the system of U.S. Pat. No. 3,991,742, the flow of water is controlled by gate valves that are manually operated. In practice most pool water heating systems that include solar and gas heating are either manually controlled or provided with a simple timer that controls a plurality of valves. Thus, the filter pump can be switched off and on by the timer, and the gate valves can be operated by solenoids and coupled to the timer. Such "controlling" of the heaters and other water-conditioning apparatus in recreational pool systems, therefore, has been relatively crude and largely based upon user convenience rather than any attempt at providing energy efficiency.

The control timers which have previously been used with recreational pool systems have also generally been "dumb" controllers in that timing functions proceeded independently and without any feedback as to operating conditions in the pool system or the functioning or failure to function of the other water conditioning apparatus. Mechanical timers will turn on a filter pump and thereby pump pool water into a solar panel located on the roof of a building for a pre-set time period, e.g., four hours, in the middle of the day. If, however, the solar panel has developed a substantial leak, the timer will cause the pump to proceed for four hours to empty the pool by pumping water into the leaking solar panel.

Similarly, when "dumb" controllers are used, one timing function may turn on the gas heater, while another turns on the filter pump. If the filter pump should fail, however, the gas heater will still be operating, with a disastrous effect.

In terms of energy savings, "dumb" timers or controllers can only roughly attempt to achieve some economy in the use of energy. Solar panels can be set to operate during the time of day when solar energy is most likely to be available, filters can be set to function at night when the demand and cost of energy are lowest, and spas can be heated only in the late afternoon and evening, when they are most generally used. Such timing of pool water-conditioning functions, however, only approximates the optimum energy usage for the pool system, and the day-to-day climatic variations which occur will result in a need for constant supervision of the control functions or inefficient energy use, or both.

The ability to truly attain an energy-efficient recreational pool system requires a controller that not only can perform timed sequencing of water-conditioning functions, but can also sense the need for these functions, sense the operation of the equipment during performance of the functions, and preferably, can effect temperature switching as well as timed switching of the water-conditioning functions. Moreover, the ability to sense operation of the pool water-conditioning apparatus and to make control decisions based upon the operation of such apparatus allows the controller to protect the system against "mindless" continued operation that can eventually destroy or endanger the apparatus.

U.S. Pat. No. 3,906,928 discloses a solar-heater control system in which a limited attempt has been made to provide some feedback into a solar pool-heating system. In this patent, a solar-heat sensor is placed proximate the solar panels and is used to control the flow of water to the solar panels. While providing some improvement over a manual or time-switched system, the apparatus and method of U.S. Pat. No. 3,906,928 is relatively simplistic and inherently limited in its control functions.

A somewhat more complex control system for a recreational pool is shown in U.S. Pat. No. 3,809,116. In this system a controller is provided to maintain the liquid level in the pool within a given range. The system includes timed, demand and manual modes of operation, but basically the controller is provided by a relatively simple clock mechanism and a plurality of sensors in the form of switches that will override the clock mechanism. Still further, for most recreational pools the problem of, when to add water, pales by comparison to the water-heating and filtration problems.

OBJECTS AND SUMMARY OF THE INVENTION

A. Objects of the Invention

Accordingly, it is a object of the present invention to provide a controller for recreational pool systems which will enable enhanced efficiency in the use of energy in the operation of pool water-conditioning apparatus.

Another object of the present invention is to provide a controller and a method of controlling recreational pool systems which are capable of controlling electrically powered, pool-related apparatus based upon a combination of programmed input and actual operating conditions in the pool system.

Another object of the present invention is to provide a controller for recreational pool systems which is capable of interrelating the operation of pool water-conditioning apparatus as between a multiplicity of pools.

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Still a further object of the present invention is to provide a controller for recreational pool systems which is capable of time-based and/or temperature-based operation of the pool water-heating apparatus.

Still another object of the present invention is to provide a controller for a recreational pool system which will protect the pool water-conditioning apparatus against destructive continued operation.

Another object of the present invention is to provide a controller for a recreational pool system which can be installed as original equipment or integrated into existing pool systems.

Still another object of the present invention is to provide a controller for a recreational pool system capable of operation of a multiplicity of pool water-conditioning apparatus on an independent, interrelated, or preferential basis.

Another object of the present invention is to provide a controller for a recreational pool system which is capable of sophisticated and complex control functions and yet is reliable and fail-safe in its operation.

Another object of the present invention is to provide a controller for a recreational pool system which is relatively inexpensive to construct and install, provides greatly increased flexibility of operation, and can be readily adapted for control of a wide variety of different pool system configurations.

The controller and method of controlling recreational pool systems of the present invention has other objects and features of advantage which are set forth in more detail in the following description of the preferred embodiment or will be apparent from the accompanying drawing.

B. Summary of the Invention

The recreational pool system controller of the present invention includes a plurality of sensing apparatus formed and positioned to sense conditions in the pool system, actuating means formed and coupled to electrically powered apparatus, such as water-conditioning apparatus, for actuation of the same, and programmable input means formed for receipt and storae of time sequence input and temperature input and formed to produce logic signals based upon such input. The controller also includes a circuit coupling the sensing apparatus, actuating means and input means together for control of the operating parameters of the pool system, and the improvement in the controller of the present invention is comprised, briefly, of providing the circuit as a logic circuit formed with a plurality of logic gates coupled to logic conversion means formed to convert signals from the sensing apparatus and the input means and formed to drive said actuating means only upon the existence of a sequence of predetermined logic states in the logic circuit. In the improved controller feedback from sensing apparatus in the pool system is combined by logic gates with input from the user of the controller to control such functions such as pumping, valve operation, solar water heating, non-solar water heating, filtration, spa operation, pool sweep operation, and hydromassage. The ability to program these functions with the controller on a timed- or temperature-switched basis enables the pool system to maximize the use of available solar energy and minimize the use of non-solar energy for both heating and filtration.

DESCRIPTION OF THE DRAWING

FIG. 1 is a hydraulic and electrical schematic representation of a recreational pool system having a controller constructed in accordance with the present invention.

FIG. 2 is a key diagram interrelating the portions of a block diagram for a controller constructed in accordance with the present invention.

FIG. 3 is a block diagram of a temperature input portion of the controller of the present invention.

FIG. 4 is a block diagram of a temperature logic portion of the controller of the present invention.

FIG. 5 is a block diagram of a timing portion of the controller of the present invention.

FIG. 6 is a block diagram of a hydromassage portion of the controller of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Pool System

The controller of the present invention can be advantageously employed to control the operating conditions of a pool system having a single pool, such as a swimming pool or a hot tube, but the many advantages of the present controller are best illustrated by a recreational pool system having a plurality of pools. As shown in FIG. 1, a spa 21 is installed in a position closely adjacent to a conventional swimming pool 22.

As is common for most pool systems, the pool system of FIG. 1 includes a variety of electrically powered, pool water-conditioning apparatus formed to heat, filter, agitate, clean and aerate the pool water. Additionally, other electrically powered apparatus may be employed in the pool system, such as lights around and in the pool and/or spa. Hydraulic circuit means, generally designated 24 and shown in FIG. 1 as relatively thick solid lines, couples the various water-conditioning apparatus for spa 21 and pool 22 for the flow of pool water through the water-conditioning apparatus in accordance with commands from controller means 26, which in the preferred form is electrically coupled by conductor means, generally designated 23 and shown in FIG. 1 by relatively thin lines, to the pool water-conditioning apparatus.

As used herein, the expression "pool" shall include swimming pools, spas, hot tubs or other recreational pools of water. The expression "pool water" shall similarly mean water that is circulating in the pool system, whether or not it is directed to or from the swimming pool, spa, hot tub or the like. Moreover, as used herein the expressions "pool related conditioning apparatus" and "conditioning apparatus" shall include apparatus for heating and filtering the pool water and shall further include electrically powered or actuated pumping apparatus, valves, lighting, apparatus to aerate the pool water and apparatus to clean the pool.

Hydraulic Circuit

In the pool system of FIG. 1, a conventional swimming pool filter 27, together with its filter pump 28, are coupled by conduit 29 to an intake valve 31. Extending from valve 31 is a first conduit 32, that terminates in intake inlet 33 in swimming pool 22, and a second conduit 34, which terminates in intake 36 located in spa 21. The intake valve 31, therefore, can be operated so that pump 28 will withdraw water selectively from either

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the spa or the swimming pool and pump the same into filter 27 for filtration purposes.

After filtration, the pool water passes through check valve 37 in conduit 38 to valve 39. The swimming pool system of the present invention is provided with solar water-heating apparatus, such as solar panels 41, and non-solar water-heating apparatus, such as gas heater 42. Accordingly, valve 39 is coupled to conduit 43 for flow of water to solar panels 41 and is also coupled to conduit 44 for the flow of water to gas heater 42. The return of pool water from solar panels 41 is provided by conduit 46 that preferably joins conduit 44 in advance of gas heater 42 so that both solar and non-solar water heating can be employed in series if desired.

In order to purge air flow from solar panels 41, which air would reduce panel efficiency if trapped in the panels, conduit 43 is coupled to a lower side 40 of the panels while outlet conduit 46 is coupled to an upper side 55 of panels 41. As water is introduced into the panels, water and air rise to outlet conduit 46, and the panels are purged of air for maximum heat transfer to the pool water.

When the flow of pool water to panels 41 is terminated, for example by switching valve 39 (also referred to as the "solar valve") for the flow of water to gas heater 42, vacuum release 60 permits air to enter the panels, and water will drain down through conduit 43 to conduit 50. Drain-down check valve 45 permits the flow of water through conduit 50 and back through filter pump 28 to the pool or spa. If pump 28 is operating, the pool water draining from panels 41 will be pumped into the filter and to gas heater 42.

In order to control the return flow of pool water as between spa 21 and pool 22, return valve 47 is coupled to conduit 48 from gas heater 42 and is further coupled to return conduit 49 for spa 21 and to return conduit 51 for pool 22. By selection of the position of intake valve 31 and return valve 47, therefore, it is possible to filter and heat water in either the swimming pool or the spa.

Moreover, valves 31 and 47 can be operated so as to empty the spa into the swimming pool for cleaning of the spa and to refill the spa from the swimming pool. Valves 31, 39 and 47 can advantageously be provided by valves constructed in accordance with U.S. Pat. No. 3,938,553.

Hydraulic circuit 24 further preferably includes a hydromassage circuit in which there is an intake conduit 52 having an inlet opening 53. Conduit 52 is connected to hydromassage or jet pump 54, and the jet pump returns the pool water through conduit 56. A manifold having a plurality of hydromassage heads 57 is connected to conduit 56, and an air intake 58 that can be adjusted so as to vary the amount of air that is injected at the hydromassage heads is also provided. Additionally or alternatively, blower 30 having air intake 25 can be coupled by conduit 35 to an air discharge manifold 20 to provide water agitation in spa 21. The construction and operation of the hydromassage circuit is conventional and well-known in the recreational pool industry.

Finally, the hydraulic circuit of the pool system of FIG. 1 includes a conduit 59 downstream of return valve 47 which leads to a pool sweep pump 61, a return conduit 62 and pool sweep apparatus 63. The pool sweep apparatus is of the type conventionally available on the market and functions to discharge pool water from the flexible arms 64 as they sweep along the bottom of swimming pool 22 so as to move sediment to the main drain.

As thus described, the various components of the hydraulic circuit of the pool system of the present invention are conventionally formed and do not by themselves constitute a novel portion of the present apparatus or method. Moreover, alternate hydraulic circuits employing the same and/or supplementary pool water-conditioning apparatus and lighting apparatus can be employed with the controller and method of the present invention.

Control Preferences and Parameters

Prior to setting forth the details of construction and operation of the controller and method of the present invention, some of the typical or most frequently desired pool system operating preferences and parameter can be described.

1. Solar Heating Preference

For virtually all recreational pool systems having a solar heating capability, solar heating, when possible, will be preferred to non-solar (usually gas or electric) heating. Obviously, solar heating preference will tend to minimize the cost of energy for the pool system. While solar heating preference will normally be desirable, the controller should also have the capability of permitting gas heating instead of or in addition to solar heating.

2. Pool or Spa Preference

The individual users of multiple pool systems may have a preference between pool 22 and spa 21 as to which body of water is heated first. This is particularly true when solar heating is also preferred. Some users, for example, prefer to solar heat the pool and gas heat the spa, if necessary. Others may use their spa more than their pool and prefer spa heating to pool heating.

3. Temperature Controlling

The operating temperature of the various bodies of water comprising the recreational pool system can vary according to the time and purpose for which they are used. Spas will normally be operated at an elevated temperature as compared to swimming pools. Neither the spa nor pool will see much use during the late night hours. Moreover, a lower temperature may be acceptable if non-solar heating is required while a higher, more comfortable temperature may be preferred if solar heating can be used. In any event, operation of the pool system in accordance with pre-set temperature criteria may be more important than operation in accordance with pre-set time criteria.

4. Switching of Spa and Pool Heating

It is desirable to be able to effect switching of pool water heating from pool to spa, or vice versa, upon a temperatures basis, a timed basis and manually. Which is preferred can vary according to pool and spa use and solar energy availability. Thus, if solar energy is more than ample to heat both the pool and spa, and spa use is only at the end of the day, the user may employ temperature switching with pool preference. If solar heating is not sufficient or the spa is to be used early in the day, timed switching—possibly with gas heating—may be employed. At any time manual override may be necessary to provide complete flexibility.

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As will be seen, therefore, various combinations of solar and gas heating, spa or pool preference, and temperature or timed switching are highly desirable to enable maximum energy efficiency for the particular use patterns of each individual pool system owner.

Controller Means

The operation of the various electrically powered, pool-related apparatus described in the hydraulic circuit is controlled by controller means. As used herein, the expression "controller means" shall include not only the circuitry controlling switching and timing, but also the sensing apparatus, actuating means and input means.

The sensing apparatus and the actuating means are both connected by electrical conductors 23 to central controller 26, and the controller preferably further includes programmable and other input means formed for receipt and storage of time sequence and temperature input and further formed to produce timing-based and temperature-based signals as a result of such input.

1. Sensing Apparatus

As can be seen in FIG. 1, a plurality of sensing apparatus are positioned to sense conditions in the pool system and are formed to produce a signal in response to these conditions. Thus, a solar temperature sensor 66 is positioned proximate solar panels 41, a water flow sensor 67 is positioned in the hydraulic circuit downstream of the solar panels to sense the flow of water from the solar panels, a pool water temperature sensor 68 is positioned to sense water temperature in pool 22, a second water temperature sensor 70 is positioned in spa 21 to sense the pool water temperature in the spa, and a water flow sensor 69 is positioned to sense the flow of water from pool sweep pump 61 back to the pool. Other sensing apparatus can be provided, for example, a flow sensor (not shown) in hydromassage return conduit 56, and a water temperature sensor downstream of the solar heater (to sense the increase in water temperature during solar heating).

As is described hereinafter in detail, the controller means of the present invention includes a logic circuit that effects control of the various electrically powered, pool-related apparatus. The sensing apparatus forming a portion of the controller means must be formed to produce a logic signal input to the logic circuit or be coupled to signal conversion means that will produce a logic signal input. Temperature sensors 66, 68 and 70 are coupled to converters and comparators which convert the temperature signals to logic signals, in a manner which will also be more fully described. Flow sensors 67 and 69 produce a logic input signal and may be directly coupled to the logic circuit.

2. Actuating Means

The controller means of the present invention further includes actuating means formed and coupled to the electrically powered, pool-related apparatus for actuation of the same. In the case of pumps 28, 54 and 61, actuating means in the form of power relays 71 that are coupled by drive circuits to the logic circuit of the controller are provided. Valves 31, 39 and 47 are actuated by valve operators 72, 73 and 74, respectively, which are coupled to the logic circuit through drive circuits. Additionally, it is preferable to provide the solar panel 41 with a drain valve 76, which is also actuated by valve operator 77 and drive circuit coupled to the logic circuit.

3. Input Means

The controller means of the present invention includes a variety of input means. Such input means includes a programmable timer which is capable of logic signal input to the controller logic circuit and which can be programmed or set by the user to input signals to the logic circuit during a plurality of desired time intervals. Additionally, input means includes temperature setting input apparatus for the spa and pool, and pool filtration setting apparatus.

Logic Circuit

As above described, the pool system, the water-conditioning apparatus and the sensing and actuating devices are more complex and sophisticated in nature than would be conventionally found in prior recreational pool systems. To the extent even portions of such equipment can be found in prior pool systems, they have been operated by "dumb" controllers which are essentially clock or timing mechanisms used to switch the equipment on or off with little or no regard to actual pool operating conditions or the functioning or failure to function of other equipment in the system.

The improved controller means of the present invention not only is capable of control and operation of the relatively complex and sophisticated pool system above set forth, but utilizes input and feedback from the pool system and the electrically powered, pool-related equipment to determine the manner in which the pool equipment is operated.

In the improved controller means of the present invention a logic circuit is provided and couples the sensing apparatus, actuating means and programmable input means together for operation of the electrically powered, pool related apparatus. The logic circuit is formed with a plurality of logic gates which require predetermined combinations of logic states to actuate the pool equipment. Thus, the logic circuit requires various combinations of logic state which depend upon events as sensed by the sensing apparatus or programmed by the input means before the various water-conditioning equipment is operated or shut down. Feedback from the pool system is thereby combined with input from the user to produce maximum energy efficiency, to protect the equipment from self-destructive operation, and to maximize the flexibility with which the pool owner may operate the pool system.

The logic circuit of the controller means of the present invention can best be understood by reference to FIGS. 2 through 6. The logic circuitry for the controller has been divided into four positions, primarily for ease of illustration in the drawings. Thus, as is shown in FIG. 2, the logic circuit includes a "Temperature Input Portion," generally designated 80 and shown in detail in FIG. 3; a "Temperature Logic Portion," generally designated 81 and shown in detail in FIG. 4; a "Timing Portion," generally designated 82 and shown in FIG. 5; and a "Hydromassage Portion," generally designated 83 and shown in FIG. 6. As will be seen from FIGS. 2 through 6, these various portions are interconnected at the common connections 84, and all three portions function together as an integrated unit.

In the broadest aspect, the logic circuit need not be electrically based. A pneumatic logic circuit, for example, can be employed in the controller of the present invention. It is preferable, however, to use an electrical logic circuit, and the details of construction of a typical

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logic circuit suitable for use with the controller of the present invention is hereafter described.

1. Temperature Input

As may be seen in FIG. 1, solar-temperature sensor 66 is positioned proximate solar panels 41, and pool water temperature sensor 68 is positioned in conduit means 32 in advance of intake valve 31, while temperature sensor 70 is positioned in spa 21. Both the solar temperature sensor and the water temperature sensors are preferably provided as current-based, solid state, linear temperature sensor-transmitters (non-thermistor type). The output of such temperature sensors would not normally be a logic signal, but all three sensors are coupled to converter means to provide a logic state input to the logic circuit. Thus, current-to-voltage converters are provided so that the signal from the temperature sensors will be converted to a voltage-based signal and can be passed to voltage-based comparators, which in turn produce digital logic outputs to the logic circuit of the present invention.

Additionally, all three temperature sensors should be provided with calibration means, and the calibration and converter apparatus are schematically illustrated in FIG. 3 by a single block at 86 for the solar temperature sensor and at 87 for the pool water temperature sensor, and at 85 for the spa water temperature sensor, although it will be understood that calibration and conversion are two separate functions. It is preferable, although not required, that the controller of the present invention include the temperature-reading means 88 which can be selectively switched by switch 89 so as to enable reading at the controller of the solar temperature, the spa water temperature or the pool water temperature. A digital display of the temperature can also be provided.

Solar temperature sensor 66 provides a temperature reading which is a combination of ambient and radiant energy. During the day, solar sensor 66, which is positioned in the sun light, reads the availability of radiant energy. At night the solar sensor senses the ambient temperature to provide a freeze-protect function, as more fully set forth hereinafter.

The provision of both pool temperature sensor 68 and spa temperature sensor 70 is used to prevent endless temperature cycling or switching of valve 31, which could occur if a signal sensor were provided in conduit 29.

In order for solar energy to be used to heat the pool water, there must be solar heat available, as compared to the pool water temperature, and it is not realistic to simply assume that solar heat will be available during certain times of the day. Cloud cover and the like may interfere or solar heat may be available longer on some days than might be assumed for an "average" day. Accordingly, the controller of the present invention includes a pool-solar comparator 91 electrically coupled to the output of solar temperature sensor 66 and pool water temperature sensor 68 and formed to produce a digital output signal to the logic circuit at conductor 92. If, for example, the solar temperature is in excess of the water temperature in the pool, a logic 1 or "true" signal exists, and if it is less, a logic 0 or "false" exists at the output of comparator 91. The logic signal from comparator 91 is communicated through conductor 92 to AND gate 93 (FIG. 4) to indicate at the AND gate that solar heat is or is not available for heating the pool water being sensed by sensor 68. Thus, conductor 92 is labeled the "Pool Solar Heat Available" line.

In a similar manner solar sensor 66 an spa water temperature sensor 70 are coupled to spa-solar comparator 101, which will input AND gate 139 (FIG. 4) with a logic 1 signal through conductor 79 when the solar temperature is greater than the water temperature in the spa.

The recreational pool user will want to input the controller as to the desired operating temperatures for both the spa and the swimming pool. The input means of the controller means of the present invention, therefore, includes apparatus for setting or inputting the controller as to the temperature level of the water in swimming pool 22 and in spa 21. This can be accomplished by providing the input means, in part, as temperature-setting apparatus 98, 99 and 100, which are coupled to comparators 95, 96 and 97, respectively. Comparators 95 and 97 are further connected to common conductor 102 from temperature sensor 68 for the pool water temperature so as to enable comparison of the water temperature in pool 22 with the pre-set temperatures input to the controller through setting apparatus 98 and 100.

As shown in FIG. 3, the comparator 95 compares the water temperature in the pool with the user's input or setting for the desired water temperature to which the swimming pool should be heated with solar heating. Comparator 97 compares the water temperature in the pool to a setting for the swimming pool water temperature when gas heating is employed and provides a logic output to AND gate 110 through conductor 90. Comparator 96 is input by spa temperature setting device 99 and spa water temperature sensor 70 (by conductor 105), and comparator 96 provides a logic 1 output to AND gate 136 (FIG. 4) through conductor 78 when the spa water is at a temperature below the input setting.

All of the input setting devices 98, 99 and 100 set ceilings to which water will be heated. The setting at input device 100 will normally set at the minimum temperature at which the user wishes to maintain the swimming pool. A typical setting might be 78° F. The input device 98, by contrast, would be set at a higher level, namely, a level at which the user would like to have the swimming pool heated if such heating can be accomplished through the use of the solar-heating apparatus. Thus, the setting of input device 98 might be 85° F. The spa water temperature will normally be set to be much higher than that of the swimming pool water. Input devices 99, therefore, might be set at 100° F.

a. Temperature Switching with Pool Preference

Assuming for the purpose of illustration that the controller is strapped for "pool preference" (strapping for pool or spa preference is described in detail below), and assuming further that temperature-based switching is occuring, the operation of the temperature sensors and temperature input can be set forth. If the pool water temperature is 70° F., comparator 97 will produce a digital logic 1 signal to AND gate 110, and comparator 95 will produce a digital logic 1 signal at the input to OR gate 104. The logic 1 signal from comparator 95 is also input to inverter 226 (FIG. 5) through conductors 103 and 187. A logic 0 is presented at time and temperature switching OR gate 181 (as a result of tne inverter and strapping between terminals 223 and 221), and this logic 0 signal appears at OR gate 157 and conductor 137, which in turn inputs a logic 0 (indicating "pool mode") to inverter 140 (FIG. 4). The output of inverter 140 is therefore a logic 1, which, together with the logic

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1 output from comparator 97, results in a logic 1 input to OR gate 106.

Since both gates 104 and 106 are OR gates, the logic 1 states will be present at the inputs to the next gates in the logic circuit, namely, AND gates 94 and 107. Before AND gate 94 will input OR gate 108 with a logic 1, a logic 1 signal must also be input from OR gate 148. OR gate 148 receives logic signals from both the pool-solar comparator 91 and spa-solar comparator 101. Both of these inputs have AND gates (namely, AND gates 139 and 93) interposed between the comparators and OR gate 148. Both of these AND gates are also input through conductor 137 by logic signals indicating whether the system is in the "pool mode" or "spa mode" of heating.

In the example, the system is strapped for pool preference and is in the pool heating mode. Accordingly, a logic 0 will be present in conductor 137 (as above explained). This logic 0 will be input to AND gate 139, which will therefore input OR gate 148 through conductor 115 with a logic 0. Inverter 145, however, will invert the logic 0 in conductor 137 and input a logic 1 to AND gate 93, thus inputing OR gate 148 with a logic 1 and thereafter AND gate 94.

A logic 1 at both inputs to AND gate 94 indicates that there is solar heat demand from either the spa or pool (in this case the pool) and that there is solar heat availability. A logic 1 signal is therefore input to OR gate 108 and then AND gate 109. The other input to AND gate 109 comes from a portion of the logic circuit which senses return of water from the solar panels so that the pump will not continue to pump water into a leaking solar panel. This will be more fully explained below, but conductor 170 is also input from AND gate 108 and will normally produce a logic 1 at the second input 112 to AND gate 109.

The logic 1 output from AND gate 109 is input to OR gate 124 and then to OR gate 125 in advance of the filter pump drive 126, and the filter pump is actuated. The logic 1 signal from AND gate 109 is also input to AND gate 119, which is also input with a logic 1 from conductor 122 from the solar return sensor and start up circuit for all conditions except a leaking solar panel. Thus, the output from AND gate 119 to solar valve drive 121 causes the solar valve 39 to be switched for the flow of pool water to the solar panels.

The presence of solar heat demand for the pool or spa plus solar heat availability will turn on pump 28 and switch solar valve 39 for the flow of water to solar panels 41.

Assuming further that the solar temperature sensed by solar sensor 66 is 83° F., water will be withdrawn from pool 22 (explained below) and the water temperature (75° F.) will be sensed and found to be below both the pool with gas heating (assumed to be set at 78° F.) and the pool with solar heating (assumed to be 85° F.). Moreover, the 75° F. water temperature will be below the 83° F. solar heat availability temperature. Accordingly, solar heating will occur, as above explained. Additionally, however, gas heating of the pool water may also be taking place.

Since comparator 97 is indicating that the pool temperature is below that of the pool temperature set for gas heating by input 100, and since the system is in pool mode, a logic 1 signal is input to AND gate 107. The other input to AND gate 107 can come from several sources. First, OR gate 130 must be input with a logic 1. This will occur if a logic 1 is present in conductor 131. A logic 1 will only be present in conductor 131 only if the pool system is in the spa mode, which the system can be manually forced into by input through pool/spa select switch 138. In the present example, however, the system is in pool mode, and a logic 0 will be present in conductor 131.

A second input to OR gate 130 comes from AND gate 127, which in turn receives an input through conductor 135 from the temperature-time switching OR gate 181. Since it has been assumed that temperature switching is occuring, inverter 226 will cause a logic 0 to be present at OR gate 181, indicating pool mode, and that logic 0 signal will be input to AND gate 127 and accordingly OR gate 130. The other input to AND gate 127 will be described when considering operation of the system in spa mode.

The final input to OR gate 130 comes from AND gate 120. AND gate 120 is input from gas enable input switch 132 and conductor 150, which is coupled to Timing Portion 82 of the circuit. Accordingly, if the timing portion of the circuit is programmed for operation of the filter pump and the system is manually input by the gas enable switch 132, a logic 1 will be present from AND gate 120 and input to OR gate 130 and AND gate 107 to drive gas heater actuating circuit or driver 134 and turn on the gas heater.

Both gas heating and solar heating of the pool water will take place; however, in order to conserve energy, gas heating requires manual input through pool gas enable switch 132. Without such input only solar heating will occur when solar heating is available. In fact, in the logic circuit illustrated, gas heating of the pool will not occur even if there is a gas heat demand and no solar heat available for a system strapped for pool preference, unless gas heat enable switch 132 is input to permit gas heating. Leaving the gas enable switch in an "on" position will result in automatic gas heating of the pool to the temperature set for the pool with gas heating, even at night, unless the filter pump is not programmed to operate, which it normally will be at night, as will be set forth below.

Accordingly, the system is constructed to permit gas heating in the pool mode, but to favor solar heating and further to require a conscience override to achieve gas heating in the pool mode. Moreover, if solar heating is available, gas heating will be augmented by solar heating.

Returning to the numerical example, as the pool water temperature rises to 78° F., the preset pool with gas heating level, the gas heat demand signal will become a logic 0, and the gas heater, if enabled, will shut down for failure to receive a logic 1 input from OR gate 106. Comparator 95, however, will still indicate that there is a pool solar heat demand and produce a logic 1 "true" signal, since the preset pool temperature with solar heating was 85° F.

Solar heater 41 will continue to heat the pool water until the pool water temperature rises to 83° F. When the pool water temperature reaches 83° F., however, comparator 91 will no longer produce a "true" solar-heat-available signal, and solar heating will terminate. If the solar conditions change and more solar energy is available, the solar heater will again be actuated and continue to heat the pool water until the preset water temperature of 85° F. is reached. Once this upper temperature is reached, heating of the pool will cease even though solar heat is available.

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Once pool water in pool 22 is heated to 85° F., the logic 0 signal from comparator 95 will be communicated to inverter 226 through conductors 103 and 187 and inverted to a logic 1 signal indicating that the system is now in spa mode. The logic 1 signal from inverter 226 is input through OR gates 181 and 157 and back through conductor 137 to the Temperature Logic Portion of the circuit, and more particularly AND gates 139 and 136 (as well as inverters 140 and 145, which now invert to logic 0 signals).

If the solar heat availability temperature has risen to 95° F. and the spa water temperature is currently 90° F., comparator 101 will also input AND gate 139 with a logic 1. The result is a logic 1 input to OR gate 148 and AND gate 94 indicating spa solar heat availability. Since the preset spa temperature is 100° F., comparator 96 indicates that there is a spa heat demand in that the spa water temperature is only 90° F. A logic 1 signal is present at AND gate 136 from comparator 96 and from conductor 137 (spa mode) and such signal is accordingly input to OR gates 104 and 106. The input to OR gate 104 is present at AND gate 94 indicating both spa solar heat demand and spa solar heat availability. The spa is, therefore, solar heated until the temperature rises to 95° F. Switching of the valves 31 and 47 for flow of water to and from the spa in response to the spa mode signal will be described below.

Once the pool water in spa 21 reaches 95° F., however, further circulation of the pool water into the solar panels would only cool the pool water. Comparator 101 will produce a logic 0 signal indicating there is no more solar heat available to heat pool water in spa 21. This in turn will input AND gate 139, OR gate 148 and AND gate 94, thus shutting down solar heating.

As set forth above, the logic 1 signal from comparator 96 indicating spa heat demand is input to logic OR gate 106, as well as OR gate 104. When the pool water in the spa rises to 95° F. solar heating shuts down, but spa heat demand continues because the preset spa temperature is 100° F. Thus, the logic 1 signal OR gate 106 is present at AND gate 107. The other input to AND gate 107 from OR gate 130 can also be a logic 1. If the manual pool/spa switch is depressed, a logic 1 will be present at OR gate 130 from conductor 131.

Even if there is no manual input, the presence of a logic 1 signal at the temperature-time switching OR gate 181 (FIG. 4) results in a logic 1 input (through conductor 135) to AND gate 127. The other input to AND gate 127 is from OR gate 200, which is input from one of two sources. First, OR gate 200 is input from inverter 149 from OR gate 148. Since the output of OR gate 148 indicates whether or not there is spa or pool solar heat available, and since in the example there is no solar heat available, the logic 0 at the output of OR gate 148 is inverted by inverter 149, and a logic 1 input to OR gate 200, AND gate 127, OR gate 120 and AND gate 107. This produces automatic gas heating of the spa when solar heat is no longer available.

The other input to OR gate 200 in spa solar preference override switch 152. This switch enables the user to force gas heating of the spa, even though solar heating is available. Thus, when solar heating of the spa is available, the input to inverter 149 from OR gate 148 will be a logic 1, which is inverted to a logic 0. Switching switch 152 to an "on" position, however, will input OR gate 200, AND gate 127, OR gate 130 and AND gate 107 with a logic 1, causing gas heating in addition to solar heating. Again it is a feature of the present logic circuitry that a manual override is necessary to cause gas heating of the pool water in the spa when solar heat is available.

Once the spa is heated to 100° F., all gas and solar heating is shut down, since there is no more heat demand for either the pool, now at 85° F., or the spa, now at 100° F.

b. Temperature Switching with Spa Preference.

In the previous example the system was strapped between terminals 221 and 223 for temperature switching with pool preference. In some instances users may wish to heat spa 21 in preference to pool 22. This may be accomplished by strapping between terminals 221 and 222, which causes the temperature-time switching OR gate 181 to receive input from conductor 224 instead of conductor 187.

The spa preference temperature switching results from the output of comparator 96. If there is spa heat demand, a logic 1 is communicated from comparator 96 through conductors 78 and 236 to AND gate 237. The logic 1 signal from AND gate 237 "spa mode" and is returned to the Temperature Portion of the logic circuit through conductors 135 and 137 to solar heat pool water in the spa, as above described under the temperature switching, pool preference section.

When the pool water in the spa is heated to the preset temperature (100° F.) a logic 0 from comparator 96 is input to AND gate 237 and OR gate 181, switching the system to pool mode. The logic 0 at OR gate 181 is inverted at inverters 140 and 145 to activate AND gates 93 and 110, which control pool heating. Pool heating then occurs as described under the temperature switching with pool preference section.

Thus, a spa preference strapping will cause heating of the spa first and then the pool, while pool preference strapping causes heating of the pool first and then the spa. In either pool or spa preference gas heating will not occur unless there is a manual override, or the system is in the spa mode and no solar heat is available. The exception for spa heating by gas when no solar is available is believed to be an acceptable energy use since the size of the spa and the amount of heating required will be relatively small.

c. Time-based Mode Switching.

The logic circuit of the present invention is capable of time-based as well as the above-described temperature-based mode switching. In time-based operation the heating in spa mode and pool mode may be determined by programmable timer 178 (FIG. 5), as well as by the temperature of the pool water.

For the purpose of illustration assume that the system is strapped for pool preference. Moreover, assume that at 5:00 p.m. each evening the pool owner wants to heat the spa for 2 hours, regardless of whether or not the pool is heated to 78° F. This condition may occur regularly during winter months. Programmable timer 178 will produce a logic 1 signal in conductor 179 which inputs OR gate 181. The system will switch to spa mode even though the temperature switching input to OR gate 181 is a logic 0.

The logic 1 from timer 178 through OR gate 181 is communicated to activate AND gates 139 and 136 through conductors 183 and 137. Usually there will be no solar heat available and a logic 0 output from OR gate 148 to inverter 149 will activate the gas heater if there is spa heat demand. When the spa reaches 100° F.,

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